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The ROSETTE DISEASE OF WHEAT AND ITS CONTROL



THE ROSETTE DISEASE OF WHEAT was first discovered in the United States in Madison County, Ill., in April, 1919. It was subsequently found in other parts of Illinois and in Indiana.

Where conditions for the disease are favorable, the rosette disease may ruin the affected crop. Usually, however, the disease occurs in more or less irregular, scattered spots of different sizes. In all except the most severely affected fields, the reduction in yield has been less than 20 per cent.

The rosette disease is recognized in the field in the spring by stunted and rosetted plants and by bunchy dying plants in the diseased spots. All plants affected with this disease produce tillers excessively and look bunchy. At first they are dull blue in color, but they subsequently turn brown and often die.

In the final stages of the disease, the plants show considerable rotting of the roots and a brown basal rot of the tillers underground.

In late spring this disease may be confused with Hessian fly injury. In both cases the color of the affected plants is about the same. The rosette disease, however, shows no symptoms in the fall, while the fly causes marked injury. Later, rosette-diseased plants may be distinguished by the much greater tendency to tiller.

The cause of the rosette disease has not yet been determined. It may be controlled by sowing resistant varieties.

Numerous varieties have been studied to determine their relative resistance to the disease. Red Wave, Early May, Shepherd, and Turkey are particularly immune. Fultz and Fulcaster are highly resistant. Harvest Queen, known locally as Salzer's Prizetaker and Red Cross, is almost completely susceptible.

THE ROSETTE DISEASE OF WHEAT AND ITS CONTROL.¹

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DISCOVERY OF THE ROSETTE DISEASE.

THE PRESENCE of the rosette disease in winter wheat was discovered about the middle of April, 1919, through a report from the county agent of Madison County, Ill., that wheat near Granite City was being severely injured by some disease. Later, this disease was found in other parts of Illinois and in Indiana.

Shortly after the discovery of this trouble the name "take-all" was applied to it, tentatively, on account of certain points in which it resembled the Australian take-all of wheat. Extensive field and laboratory investigations have shown that it is distinctly different from Australian take-all, and the name "rosette disease" has been applied to the disease occurring in Illinois and Indiana.

ECONOMIC IMPORTANCE OF WHEAT ROSETTE.

Under conditions favorable for its development the rosette disease may cause considerable damage. In the spring of 1919 some of the wheat fields in Madison County, Ill., were so badly affected that they were plowed up and planted to other crops. In one case a 40 per cent actual reduction was caused in the total yield of grain in a 50-acre field in that county. In several cases observed the reduction in yield has been about 20 per cent; the loss in most cases up to this time has been much less.

Under conditions favorable for the wheat crop, the diseased plants may send up secondary tillers which form a thin to fairly thick stand

¹All the field experiments for the control of the rosette disease have been conducted on fields in the "American bottoms" of the Mississippi River near Granite City, Ill., in cooperation with the Illinois Agricultural Experiment Station, and at Wanatah, Ind., in cooperation with the Indiana Agricultural Experiment Station. Certain laboratory and greenhouse studies have been conducted in cooperation with the department of plant pathology at the Wisconsin Agricultural Experiment Station. In 1919 the field-laboratory studies were conducted in the laboratories of the Missouri Botanical Garden, St. Louis, Mo., through the kindness of Director George T. Moore and Dr. B. M. Duggar. In 1920 the field-laboratory studies were made in the laboratories of the Granite City, Ill., high school, through the courtesy of Superintendent L. P. Frohardt.

and produce some grain. These tillers mature later than plants that have not been affected by the disease and usually produce only shrunken grain. In badly infested fields this unevenness in ripening may make it advisable to postpone harvesting until the healthy grain is overripe, or, if possible, to divide the field and harvest the diseased area at a later date. Losses due to shattering of overripe grain and the lower yields and poorer quality of grain produced on infested land must be taken into consideration in deciding the date of harvest.

GEOGRAPHIC DISTRIBUTION.

So far as known the rosette disease occurs only in Illinois and Indiana. There is a possibility that it may be present in Colorado, but this has not been determined with certainty.



FIG. 1.—Portion of a spot in a wheat field infested with rosette.

The true Australian take-all has been found in Arkansas, California, Indiana, Kansas, Maryland, New York, North Carolina, Oregon, Tennessee, and Virginia, and a disease which is very similar to it, if not identical with it, has been found in Washington.

CROPS AFFECTED.

Investigations conducted thus far have not shown positively that any crop other than wheat is susceptible to the rosette disease. There are some indications that rye may be very slightly susceptible.

SYMPTOMS OF WHEAT ROSETTE.

SYMPTOMS IN THE SPRING.

The conspicuous symptoms of the rosette disease first become evident in the spring after growth of the healthy plants is well started. Distinct patches of badly dwarfed plants are found here and there in some fields without regard to the type or condition of the soil

(fig. 1). Some of these patches may be so small as to include only a comparatively few diseased plants. In fact, the diseased plants sometimes may occur one in a place, here and there, intermixed with apparently healthy plants. In such cases these diseased plants are difficult to find, and hence are commonly overlooked. Definite spots containing diseased plants usually can be recognized. The edge of such a spot generally is more sharply defined than the margins of spots caused by unfavorable soil conditions, especially poor drainage. In such spots most of the plants are diseased and therefore stunted right up to the edge of the spot (fig. 2, *B*). In spots caused by local unfavorable soil conditions all the plants usually decrease in height rather gradually from the edge toward the center (fig. 2, *A*).

In fields more severely infested, the patches may be very large and contain a high percentage of diseased plants, or they may cover even large portions of the infested fields.

Wherever found, the diseased plants in the spring show certain distinct characteristics, particularly (1) dwarfing, and a little later

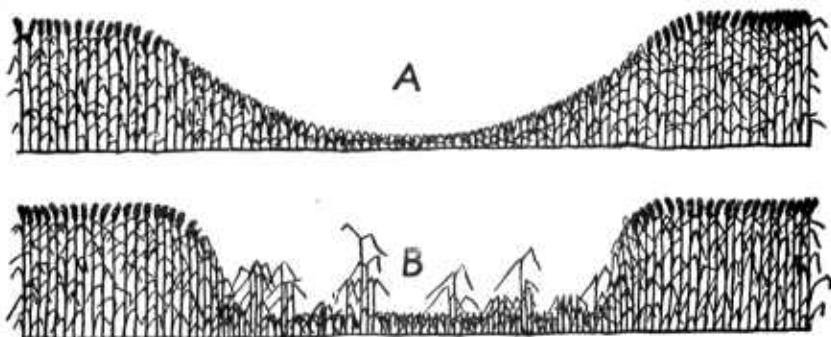


FIG. 2.—Diagram of a section of a spot caused by local abnormal soil conditions (*A*) and a spot caused by the rosette disease (*B*).

(2) abnormal dark-green coloration of the fall leaves, (3) dying of outer leaves and fall tillers, (4) usually a browning of the bases of affected plants (fig. 3), (5) excessive development of spring tillers, and (6) some plants may be killed entirely.

Early in the spring, if healthy and diseased plants growing side by side are pulled up, it will be noted that the disease is fairly well limited to individual plants which at that time show marked dwarfing but no basal browning of the living tissues. A little later the diseased plants show a browning and still later a rotting of the basal portions, that is, those parts just below the surface of the ground. The roots may not show any particular evidence of disease, or they may show some discoloration when the basal browning occurs. The diseased plants may be immediately adjacent to and intermixed with healthy plants. Along with the development of the basal browning and rotting, spring tillers become evident in excessive numbers, giving the diseased plants a bunchy appearance (fig. 4). Under certain soil conditions, especially when the soil is dry, some of the diseased plants die in the spring while still in the dwarfed stage.



FIG. 2.—Healthy winter-wheat plants and those showing the effects of rosette and Hessian fly, respectively: *A*, Healthy plant in the spring; *B* and *C*, plants of the same variety and age as in *A*, showing early and advanced stages, respectively, of the rosette, both having a bluish green color; *D*, healthy plant in late autumn; *E*, plant of the same age as *D*, infested by the Hessian fly, with the same bluish green leaf color as in *B* and *C*. (After a colored plate by McKinney and Larrimer in U. S. Dept. Agr. Bul. 1137.)

SYMPTOMS LATER IN THE SEASON.

When the healthy wheat plants are beginning to head, or the heads are in the boot, the diseased plants usually show partial re-



FIG. 4.—Wheat plants at the flowering stage, showing all stages of rosette injury. A healthy plant on the right.

covery (fig. 5) and send up one or more short, weak stems. In some cases, where soil conditions are very favorable, rather complete recovery may occur, so that the infested areas may be difficult to locate by the time the crop is mature.

When healthy plants are ripening, the diseased plants are still green. On account of this, the infested areas show conspicuously as green spots in the ripening healthy grain. Frequently, especially in wet seasons, the development of weeds in the infested areas adds to the general green effect brought about by the green condition of the diseased plants.

When the diseased plants recover sufficiently to develop heads, these are short and only imperfectly filled or not filled at all. This

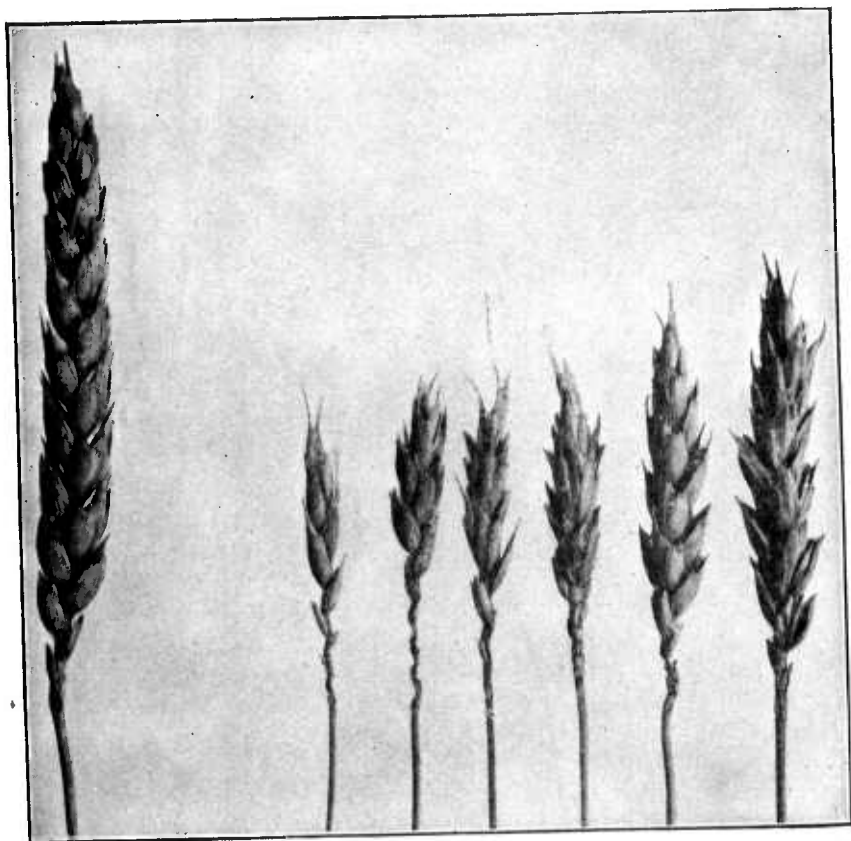


FIG. 5.—Head from a healthy wheat plant (left). Heads from plants partially recovered from rosette infection (right).

is in striking contrast with the large well-filled heads of healthy plants (fig. 5) at harvest time.

SYMPTOMS OF ROSETTE COMPARED WITH INSECT INJURIES.

At certain stages the symptoms of the wheat rosette disease somewhat resemble those caused by Hessian fly injury. In both cases the plants affected have a somewhat similar green color in the spring, different from the normal green of healthy plants. In the case of the rosette disease the color is a dark blue-green, practically identical

in color with the dark green of plants infested with the Hessian fly (fig. 3). The rosette disease does not show any symptoms in the fall, while the Hessian fly causes very noticeable fall injury. Plants infected with the rosette disease show an excessive development of tillers, while plants injured by the Hessian fly generally do not tiller as much as normal plants.

In late spring there is a possibility of confusing the two maladies, especially if there is some spring infestation of the Hessian fly in plants affected by rosette. At this time bare areas may occur in fields where diseased plants have been washed out by heavy rains. Such fields usually can not be distinguished from those suffering from a severe attack of the fly, when the infestation of either is general over the field. Wheat rosette, however, usually occurs in spots, while spring fly infestation seldom, if ever, occurs in localized areas or spots in the field. The occurrence of such field spotting is practically conclusive evidence that fly injury is not the sole cause.

In fields where both rosette and fly are present, some of the diseased plants will show fly infestation, but usually many near-by plants affected by rosette will show no evidence of such infestation. In plants suffering only from fly injury the larva or flaxseed stage of the insect or the empty flaxseed cases will be found at the base of the plant, usually inside the first leaf sheath.

The wheat-stem maggot may infest wheat fields in the fall, presenting at that time very much the same appearance as that caused by Hessian fly. It is generally not so prevalent as the fly. The plants affected by the wheat-stem maggot usually die during the fall or winter and so will not lead to confusion with rosette in the spring. These dead and more or less rotted or decayed plants in the spring contain the full-grown larvæ or pupæ of the insect.

The wheat strawworm infests plants almost invariably only in the vicinity of old wheat stubble, which is not the case with rosette. Plants are infested by the strawworm only in the spring and develop symptoms that resemble Hessian fly injury. Injury by strawworm can be distinguished from rosette by means of the bulblike swelling at the base of the infested plants, and by the absence of the excessive tillering caused by rosette.

RECURRENCE.

In 1919, when the disease was first observed, it was thought by some that the trouble was caused by the exceptionally mild winter of 1918-19, and considerable doubt was expressed whether the disease would reappear in a normal season. At the present time, however, there can be no doubt on this point, as the disease has recurred each spring since its discovery in 1919. From present knowledge and past experience there is every reason to believe that the disease will recur every year when susceptible varieties of wheat are sown on infested land.

CAUSE.

The cause of the rosette disease of wheat has not yet been determined.

CONTROL OF WHEAT ROSETTE.

Various control measures for the disease have been tested, and important progress has been made. It is known that the soil carries the causal factor, whatever it may be. Attempts to control the disease on infested land by seed treatments therefore are useless. So far there is no indication that cropping methods, summer fallow, burning the diseased stubble, or the application to the infested soil of ground limestone, fertilizers, or such chemicals as iron sulphate will control the disease at all.

LATE SEEDING.

Wheat sown very late in the fall has not been affected by the rosette disease as much as wheat sown at the usual seeding time. Late seeding can not be recommended, however, as a means of controlling the disease, for late-sown wheat is liable to winterkill and give low yields.

RESISTANT VARIETIES.

Experiments conducted with a large number of varieties and strains of winter wheat show that the disease can be controlled by the use of resistant varieties. In these experiments seed of about 200 lots of wheat was sown in rows or plats on land in Illinois and Indiana that was known to be infested. The resulting plants were examined the following spring, and the percentage of infection in each lot was recorded.

The varieties tested in plats were sown in the fall of 1919 in adjacent parallel strips, one drill width (54 inches) wide and 50 rods long, on a uniformly infested and practically level field located near Granite City, Ill. The results of the plat trials are briefly summarized in Table 1. The varieties are listed in the same order in which they were sown in the plats.

TABLE 1.—*Resistance and susceptibility of certain varieties of wheat to rosette, as shown by plat experiments conducted near Granite City, Ill., in 1920.*

Variety of wheat.		Rosette in plats.	Yield per acre.	Weight per bushel.
Local name.	True name.			
		<i>Per cent.</i>	<i>Bushels.</i>	<i>Pounds.</i>
Salzer's Prizetaker.....	Harvest Queen.....	90	8.87	54.75
Red Wave.....	Red Wave.....	0	28.33	56.75
Illini Chief.....	Illini Chief.....	25 to 30	24.08	58.00
Harvest King.....	Harvest King.....	Trace	28.83	56.50
May.....	Early May.....	0	25.61	58.50
Red Cross.....	Harvest Queen.....	73	13.51	53.00
Fultz.....	Fultz.....	2	26.20	59.50
Winter Fife.....	Jones Fife.....	(¹)	32.87	58.50
Turkey Red.....	Turkey.....	0	21.50	60.00
Fulcaster.....	Fulcaster.....	2	25.80	60.75

¹ Two plants.

The varieties and strains grown in rows were sown by hand in shallow furrows a rod long and 8 inches apart. Sowings of this sort were made in 1919, 1920, 1921, and 1922 at Granite City, Ill., and in 1921 and 1922 at Wanatah, Ind. Yields of these rows

have not been determined. A few varieties showed a high degree of susceptibility. Harvest Queen is the only widely grown variety that has been found to be highly susceptible. Several other important wheats have shown a small percentage or a trace of infection. Harvest Queen was one of the important varieties being grown by farmers in 1919 in the area of Illinois in which the rosette disease was first found. It was there known as Salzer's Prize-taker. It is a soft red beardless wheat, with white glabrous (smooth) chaff and red kernels. The name Salzer's Prizetaker is incorrectly applied to this variety, inasmuch as the original Salzer's Prizetaker has brown chaff and white kernels. Fortunately Harvest Queen (Salzer's Prizetaker) has almost disappeared from the worst infested area, since farmers have seen how susceptible it is to the disease. This variety is sometimes also called Red Cross. Another variety, also known as Red Cross, has brown chaff and red kernels and is resistant, or only slightly susceptible, to the rosette disease.

Several well-known varieties showed from 1 to 5 per cent of infection. Among these are Fultz, Jones Fife (two lots), Illini Chief, and China (Pennsylvania Bluestem). One lot of Illini Chief showed 25 per cent infection in one case.

Many of the important wheats of the United States showed no rosette infection in these experiments. Five important classes, hard red spring, hard red winter, soft red winter, common white, and club, are represented. The varieties that were found resistant are used in sowing about one-eighth of the acreage of hard red spring wheat, nearly all of the acreage of hard red winter wheat, by far the larger part of the acreage of soft red winter wheat, about one-third of the acreage of common white wheat, and about one-fifth of the acreage of club wheat. It is possible, therefore, to find among the resistant varieties one or more suited to almost any part of the United States.

On account of the large number of immune or resistant varieties it is not difficult to control the rosette disease in farm practice. In central Illinois and northwestern Indiana where wheat rosette occurs the matter of control of the disease is comparatively simple. Numerous varieties immune from rosette and adapted to these sections are known. Principal among these are Turkey and other varieties of hard red winter wheat now widely grown in these two areas. Other important wheats, of the soft red winter type, immune from rosette are: Currell, certain lots of Fulcaster and Fultz, Fultz-Mediterranean, Gipsy, Gladden, Jones Fife (two selections), Mammoth Red, Mediterranean, Michikoff, Poole, Harvest King, Portage, Red May, Early Ripe, Michigan Amber, Red Cross (red chaffed), Red Rock, Red Wave, Rudy, and Trumbull.

By sowing the hard red winter wheats of the Turkey type on infested land in areas where these are adapted and the soft red winter varieties named above in areas suited to them, it is almost certain that the rosette disease will be controlled.

CONTROL IN THE FLAG-SMUT AREA.

In southern Illinois, where flag smut of wheat (*Urocystis tritici*) occurs in the same locality with the rosette disease, additional care must be taken in choosing varieties for sowing. The varieties resistant

to both diseases are rather few in number. Farmers have substituted Red Wave and Fultz, and to some extent hard red winter wheats of the Turkey type, for the varieties that have shown high susceptibility. Red Wave and Fultz, although immune from rosette, are somewhat susceptible to flag smut. The hard red winter wheats, while practically immune from both diseases, are not entirely satisfactory from the farmer's standpoint in the southern Illinois area. Climatic conditions there are not suitable for the best development of this type of wheat.

Two beardless strains developed from plant selections made several years ago and known as Early Harvest and Shepherd appear to be desirable varieties from the farmer's standpoint. They have been immune from both diseases, yield well, and produce a good quality of soft red grain. No commercial supply of seed is yet available, but Shepherd is being increased as rapidly as possible. A number of bearded wheats have been found immune from both rosette and flag smut. The most important of these two selections of Fulcaster (known as Eversole), Stoner (Marvelous), and Red Rock. Large stocks of seed of Stoner and Red Rock are available, but not all of the stocks of these varieties grown in this area have shown entire freedom from flag-smut infection. Possibly some of this small percentage of infection is due to slight mixtures of susceptible varieties, which are likely to be found in wheat as ordinarily grown by farmers.

A group of bearded wheats with glabrous (smooth) white chaff and purple straw, belonging to the soft red winter class, has shown immunity from, or high resistance to, both flag smut and rosette. Fulcaster is the leading variety in this group. Other names under which this type of wheat is known include Bearded Purplestraw, Dietz, Lancaster, Mammoth Red, Marvelous, and Stoner. This type of wheat is widely grown under one or another of its names in Missouri, Illinois, Indiana, and other States. Large stocks of practically pure seed are available, and it is probable that if they were used on infested land in the area growing soft red winter wheat until fully immune varieties are available, rosette and flag smut would do but little, if any, damage. Field tests with Fulcaster wheat have shown it to be one of the varieties best adapted to southern Illinois. It is also known to be one of the best soft red wheats in milling and baking qualities.

Additional data are given on varietal resistance of wheat to flag smut in University of Illinois Agricultural Experiment Station Bulletin No. 242 and in United States Department of Agriculture Circular 273. Additional data on the rosette disease also can be obtained from the United States Department of Agriculture, Washington, D. C.

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